RDT

Brief

Research Investigation RI97-015

September, 1998

Missouri High Performance Concrete Update

Fiber-reinforced PCC Unbonded Overlay I-29 Atchison County

In 1996, Missouri volunteered to participate as a lead state in the AASHTO Lead State Program for High Performance Concrete. The lead state program was initiated in 1996 by the AASHTO Task Force on SHRP Implementation in an effort to implement specific "high payoff" SHRP technologies such as high performance concrete. High performance concrete (HPC) technology utilizes innovative design and construction concepts for improved pavements and bridges. As a result, pavements and bridges are constructed having longer service lives with improved performance and greater economic benefits. As a lead state in HPC technology, Missouri is committed to help further the development and implementation of HPC.

Project Description

July 1998 saw the completion of the first section of fiber-reinforced concrete pavement in the state of Missouri. The section, an unbonded fiber-reinforced concrete overlay, is located in the southbound lanes of I-29 in Atchison County between Route A and US 136. Within the total length of over four miles, eight 2500' test sections have been established. Three of the test sections are reinforced with steel fibers and are 9", 6" and 5" thick. Another three test sections, also 9", 6" and 5" thick, are reinforced with polyolefin fibers. The two remaining test sections will serve as control sections and are non-reinforced jointed concrete overlays at 9" and 11" thick. Joint spacing in the fiber-reinforced test sections varies from 15' to 200' and the joint spacing in the non-reinforced sections is 15'.

MoDOT, in cooperation with the University of Missouri - Columbia, previously completed a laboratory evaluation of fiber-reinforced mixes incorporating several fiber types at varying dosage rates. Based on toughness test results from this study and manufacturer's recommendations, the following two fibers were chosen for the I-29 overlay:

3M 50mm polyolefin fibers at a dosage rate of 25 lbs./cu. yd.
Bekaert 60mm steel fibers at a dosage rate of 75 lbs./cu. yd.

Construction

The concrete paving contractor for the project was Cedar Valley Corp. of Waterloo, Iowa. The original 9" reinforced PCC pavement received pavement repair and a 1" asphalt debonding layer. The fiber-reinforced concrete overlay mix had an average water to cementitious materials ratio of 0.39 and Bethany Falls limestone coarse aggregate of a 1/2" maximum gradation. The ratio of fine aggregate to coarse aggregate was 45/55.

Non-uniform distribution of fibers in the concrete was observed at times during construction. This condition existed with both fiber-reinforced mixes, but was

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observed more frequently in the polyolefin fiber-reinforced sections than in the steel fiber-reinforced sections. Mixing times were increased and the order of mixer loading was altered to address this concern. Both solutions seem to increase uniformity of the fiber distribution in the concrete.

In lieu of the conventional transverse tining texturing methods, the contract required diamond grinding of the overlay 21 days after construction for smoothness and rideability. Interim finishing required a burlap drag. It was discovered during construction that a better finish could be achieved with an unweighted carpet drag rather than the burlap drag. The fibers became caught in the burlap which led to some fibers and aggregate being pulled from the top layer of the overlay. The carpet drag remedied the problem. Following grinding, profilograph readings averaged less than 11 in./mile on the new overlay using a zero blanking band which resulted in a contract bonus.

Project Research

Research on the fiber-reinforced concrete is a joint effort between MoDOT and the University of Missouri - Columbia. Project research includes laboratory testing of specimens collected during paving and monitoring pavement performance through field distress surveys. The laboratory testing will be performed on both the fiber-reinforced concrete and the non-reinforced concrete and will include the following:

7 and 28 day compressive strength

7 and 28 day flexural strength

toughness testing

fatigue endurance

Pavement distress surveys have been completed for 1 day, 2 weeks and 1 month after construction. Additional distress surveys are scheduled for 3 months, 6 months, 1 year and periodically throughout the pavement service life to provide a history of performance.

Nearly no cracks have appeared in the non-reinforced concrete sections. It should be noted, however, these sections were constructed with 15' joint spacings. In comparison, the 15' and 30' panels in both the steel and polyolefin fiber-reinforced sections also experienced nearly no cracks.

Initial performance results of the fiber-reinforced sections are positive. Both the polyolefin and steel fiber-reinforced sections have experienced some cracks in the 60' and 200' panels, with the polyolefin sections showing fewer cracks than the steel sections. Inclusion of reinforcing fibers in the concrete should lead to improved post-crack performance of the overlay, extending the pavement's useful service life.

Project Cost

The long term advantages of an extended service life, requiring less maintenance, and the possibility of constructing a pavement which is thinner and requires less material than the current practice should offset the additional cost of including reinforcing fibers in the concrete. The additional cost over conventional concrete for the steel fiber-reinforced concrete was $47.00/cu. yd. and $60.00/cu. yd. for the polyolefin fiber-reinforced concrete. A cost per mile comparison between the non-reinforced control sections and the 5" fiber-reinforced sections is shown below.

11" Non-reinforced	(4302 cu. yd./mi.) ($79.00/cu. yd.) = $340,000/mi.
9" Non-reinforced	(3520 cu. yd.mi.) ($78.96/cu. yd.) = $278,000/mi.
5" Polyolefin fiber-reinforced	(1956 cu. yd./mi.)($136.76/cu. yd.) = $268,000/mi.
5" Steel fiber-reinforced	(1956 cu. yd./mi.)($123.62/cu. yd.) = $242,000/mi.

The numbers shown above represent the cost for furnishing and placing a 24' wide overlay and does not include any repair of the existing pavement, debonding layer or diamond grinding.

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